

NUTRIENT SOLUTIONS FOR ORCHIDS

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In a previous paper ('33) the author reported the result of growing seedlings of *Cattleya Trianae* Linden & Rchb. f., on three-salt solutions of various ratios, all having a total osmotic concentration of one atmosphere. It was found that the best growth was associated with solutions having low concentrations of phosphate ions. All other ions were varied between wide limits with but little apparent effect.

There is ample evidence in the literature of plant nutrition to support the belief that any set of nutrient salts at a given total concentration will exhibit more or less definite ratios for optimum growth, particularly if external conditions be kept constant. Since the effectiveness of any salt ratio depends upon the total concentration, it is not possible to compare the effects of specific ions in solutions differing in the total amount of salt present. The addition of extraneous ions may modify the permeability of the protoplasm and disturb the effectiveness of a given salt ratio. The solutions studied in the present work differ from each other in many respects, and the biological value of specific ions is therefore modified or obscured so that no comparison on the basis of ionic composition may be made. Such a comparison is possible only with the triangular series of salt ratios at a given total osmotic concentration.

In the previous paper, the nutrient solution of La Garde ('29) was cited as a very favorable medium for the germination and growth of orchids, but its effectiveness could not be attributed to the specific concentrations of the potassium or phosphate ions. The present study was carried out to test this further, and to ascertain which of several published nutrient solutions were most satisfactory for the germination of orchid seedlings.

The technique was the same as that described in the previous paper. The seeds were *Cattleya Trianae* Linden & Rchb. f. and from the same pod as those used for the triangular studies. The flasks were inoculated June 10, 1932, and the measurements were taken January 21, 1933. The molecular compositions of the solutions used are indicated in table 1; their composition in parts

TABLE I
COMPOSITION OF THE VARIOUS SOLUTIONS IN GRAMS PER LITER

Solution	$\text{Ca}_3(\text{PO}_4)_2$	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	KNO_3	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	$\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$	KCl	KH_2PO_4	CaCl_2	NaCl	$(\text{NH}_4)_2\text{SO}_4$	K_2HPO_4	NH_4NO_3	$(\text{NH}_4)_2\text{CO}_3 \cdot \text{H}_2\text{O}$
La Garde ('29)				1.000	1.000		1.000	1.00				.500	.500
Crone, in Benecke and Jost ('24)	.250	.500	1.000	.500									
Knudson ('22)				.250	1.000					.500	.250		
Sachs, in Benecke and Jost ('24)	.500	.500	1.000	.500					.500				
Pfeffer, in Duggar ('24)			.200	.200	.800	.100	.200						
Shive A ('15a)				3.698	.853		2.451						
Schimper, in MacDougal ('01)			.431	.431	1.724				.431		.431		
Shive B ('15b)				4.930	1.228		1.960						
Knop, in Benecke and Jost ('24)				.250	1.000	.120	.250						
Tottingham ('14)			.495	3.574	2.363		1.770						
Hansteen-Cranner, in Benecke and Jost ('24)				.615			.450	.56	.150	1.18			
Zinzadze ('26)	.077	.083		.170		.123						.066	

per million, in table II; and the growth data, in table III. All solutions received 1 cc. of a M/200 suspension of ferric phosphate per liter prepared as described by Livingston ('19).

TABLE II
COMPOSITION OF THE SOLUTIONS IN PARTS PER MILLION
OF THE NUTRIENT COMPONENTS

	Ca	Mg	K	PO ₄	SO ₄	NO ₃	NH ₄	N (Total)	Cl
La Garde	360	98	287	698	390	388	283	308	658
Crone	213	49	387	153	474	623		140	
Knudson	169	25	112	137	462	525	137	225	
Sachs	310	49	387	307	474	623		140	302
Pfeffer	135	20	186	140	78	545		123	
Shive A	144	360	703	1710	1440	448		101	
Schimper	291	42	260	235	168	1071		241	260
Shive B	208	480	563	1368	1930	646		145	
Knop	169	25	134	175	98	525		118	58
Tottingham	399	347	700	1235	1390	1547		348	
Hansteen- Cranner	202	60	129	314	1098		322	250	458
Zinzadze	49	17	62	47	112	51	15	23	58

TABLE III
GROWTH DATA, BASED UPON THE AVERAGE OF 25 SEEDLINGS

Solution	Height in microns	Diameter in microns	% Total salt	pH at planting	pH at end of experiment
La Garde	4243	1590	.400	4.9	3.8
Crone	3760	1213	.225	5.5	4.5
Knudson	3360	1145	.200	5.0	4.5
Sachs	3258	1300	.300	5.1	4.5
Pfeffer	2953	1135	.150	5.0	4.6
Shive A	2908	1250	.700	4.8	4.5
Schimper	2835	1223	.345	5.1	4.5
Shive B	2793	1213	.812	4.8	4.4
Knop	2360	1145	.162	5.0	4.5
Tottingham	1868	900	.820	4.9	4.5
Hansteen- Cranner	No growth	No growth	.295	4.9	3.9
Zinzadze	No growth	No growth	.052	5.1	3.7

The fact that no growth occurred on the solution of Hansteen-Cranner and of Zinzadze was probably due to instability of the

pH of these solutions as shown by their high acidity at the end of the experiment. In this connection it is interesting to note that

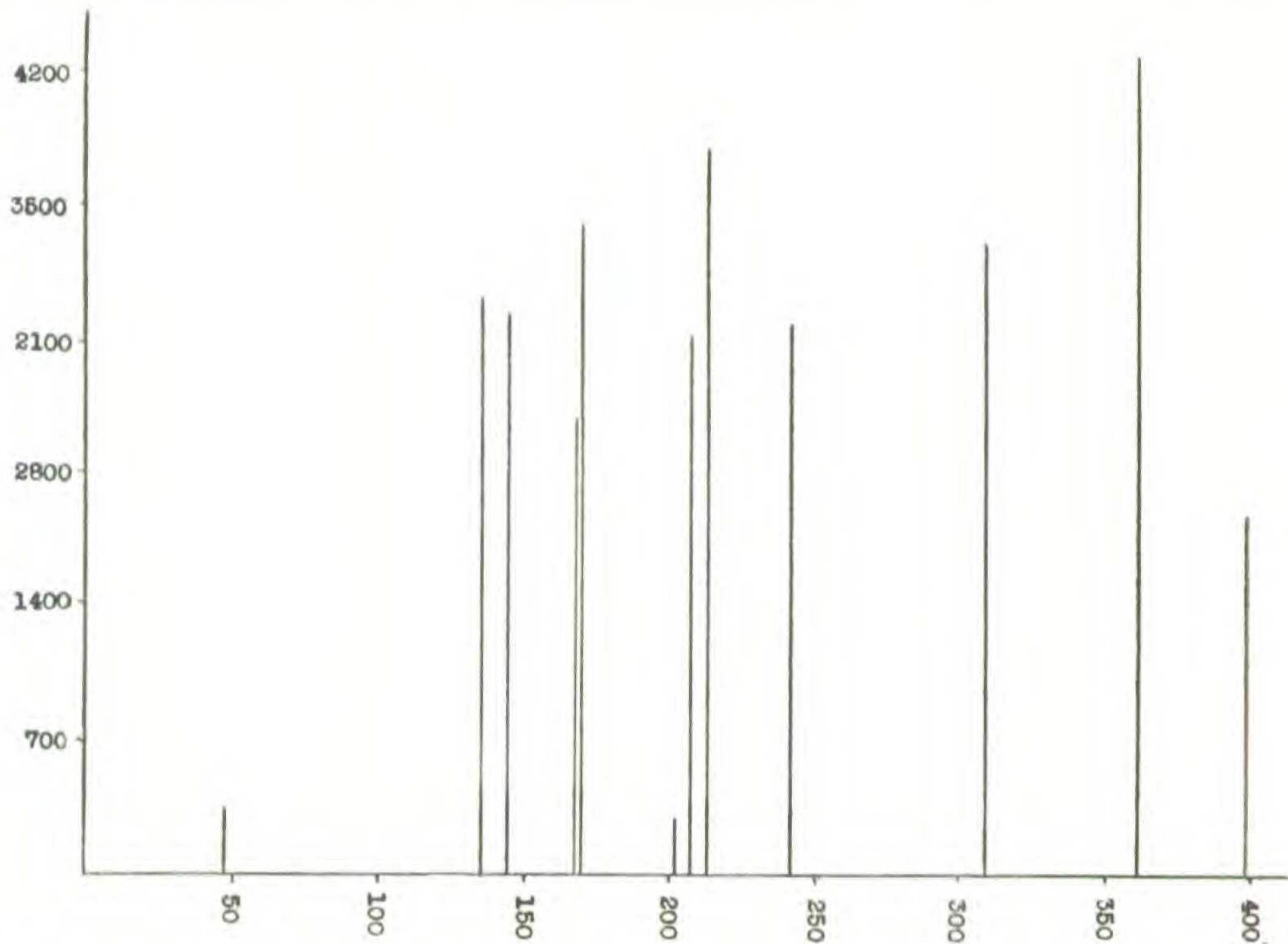


Fig. 1. The relation of growth to calcium content. Zinzadze, Pfeffer, Shive A, Knop, Knudson, Hansteen-Cranner, Shive B, Crone, Schimper, Sachs, La Garde, Tottingham.

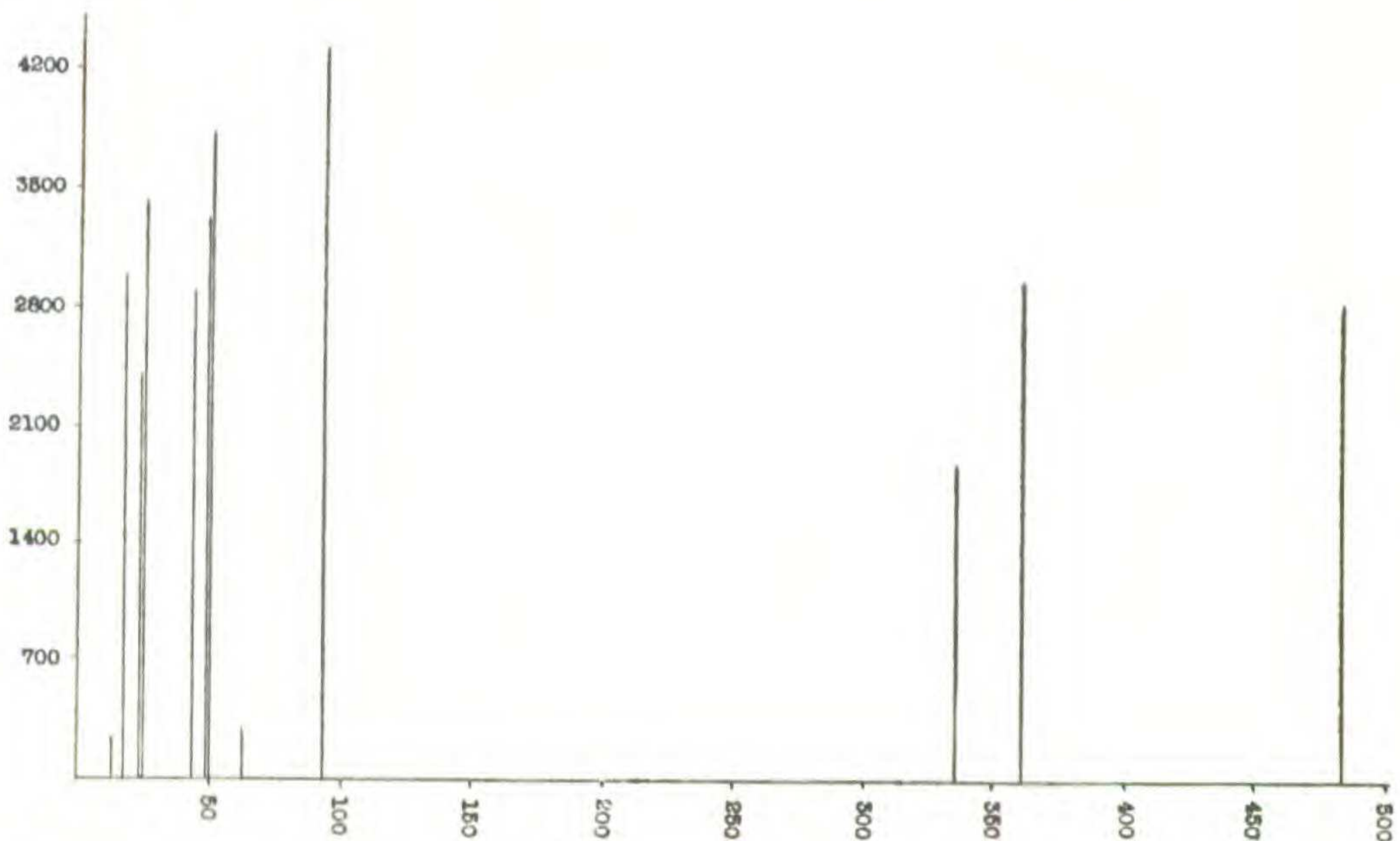


Fig. 2. The relation of growth to magnesium content. Zinzadze, Pfeffer, Knop, Knudson, Schimper, Sachs, Crone, Hansteen-Cranner, La Garde, Tottingham, Shive A, Shive B.

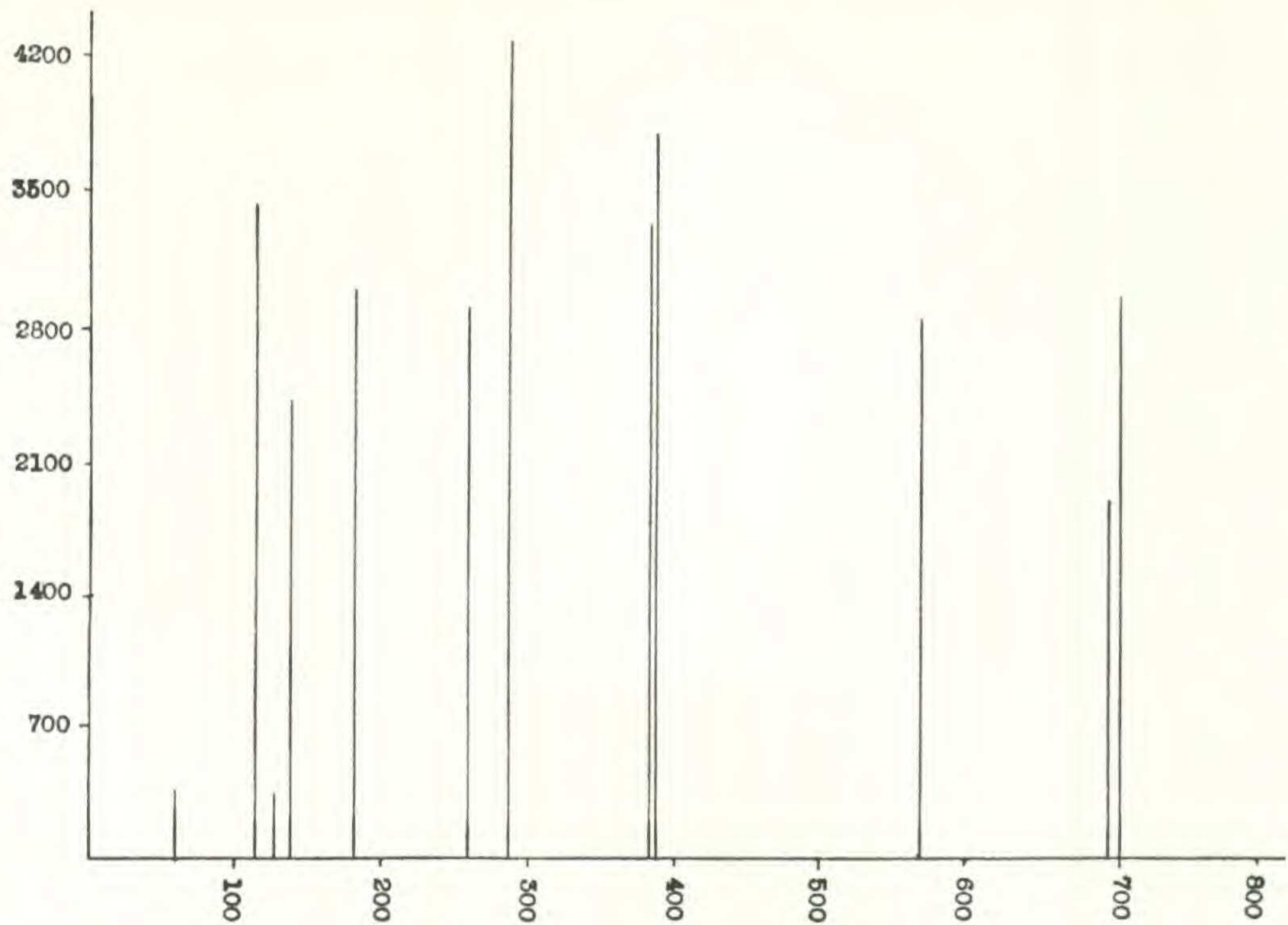


Fig. 3. The relation of growth to potassium. Zinzadze, Knudson, Hansteen-Cranner, Knop, Pfeffer, Schimper, La Garde, Sachs, Crone, Shive B, Tottingham, Shive A.

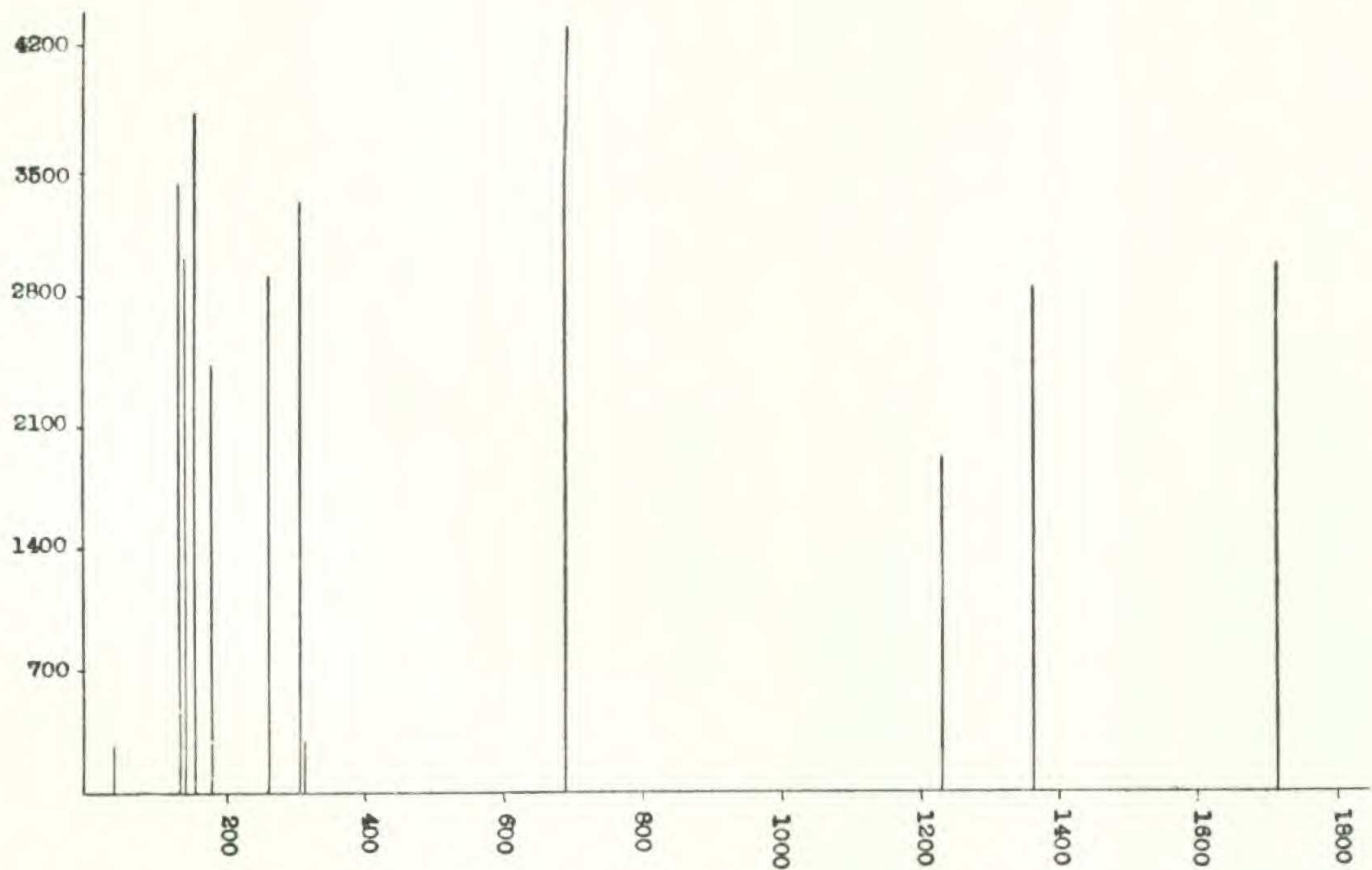


Fig. 4. The relation of growth to phosphate. Zinzadze, Knudson, Pfeffer, Crone, Knop, Schimper, Sachs, Hansteen-Cranner, La Garde, Tottingham, Shive B, Shive A.

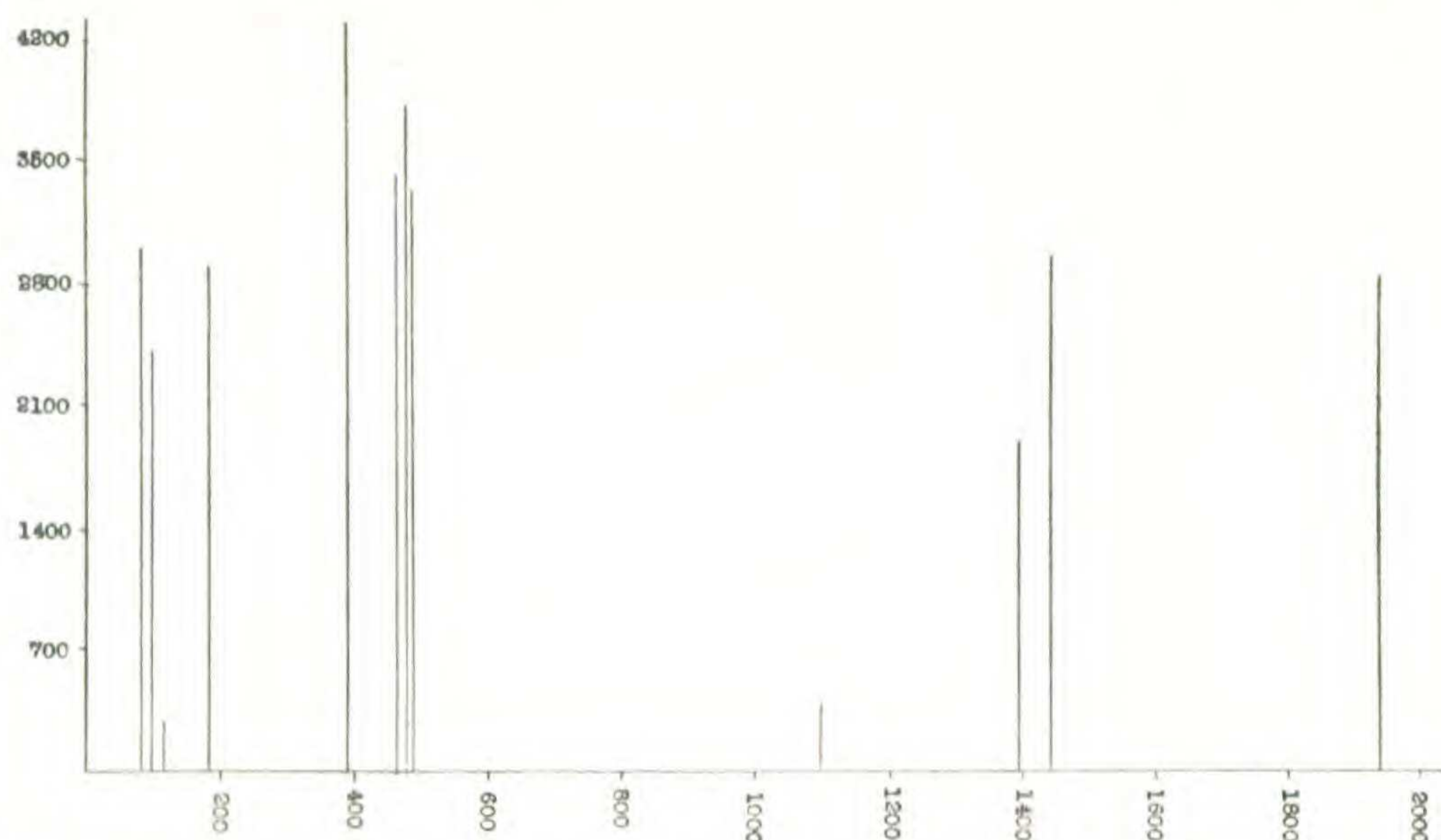


Fig. 5. The relation of growth to sulphate. Pfeffer, Knop, Zinzadze, Schimper, La Garde, Knudson, Crone, Sachs, Hansteen-Cranner, Tottingham, Shive A, Shive B.

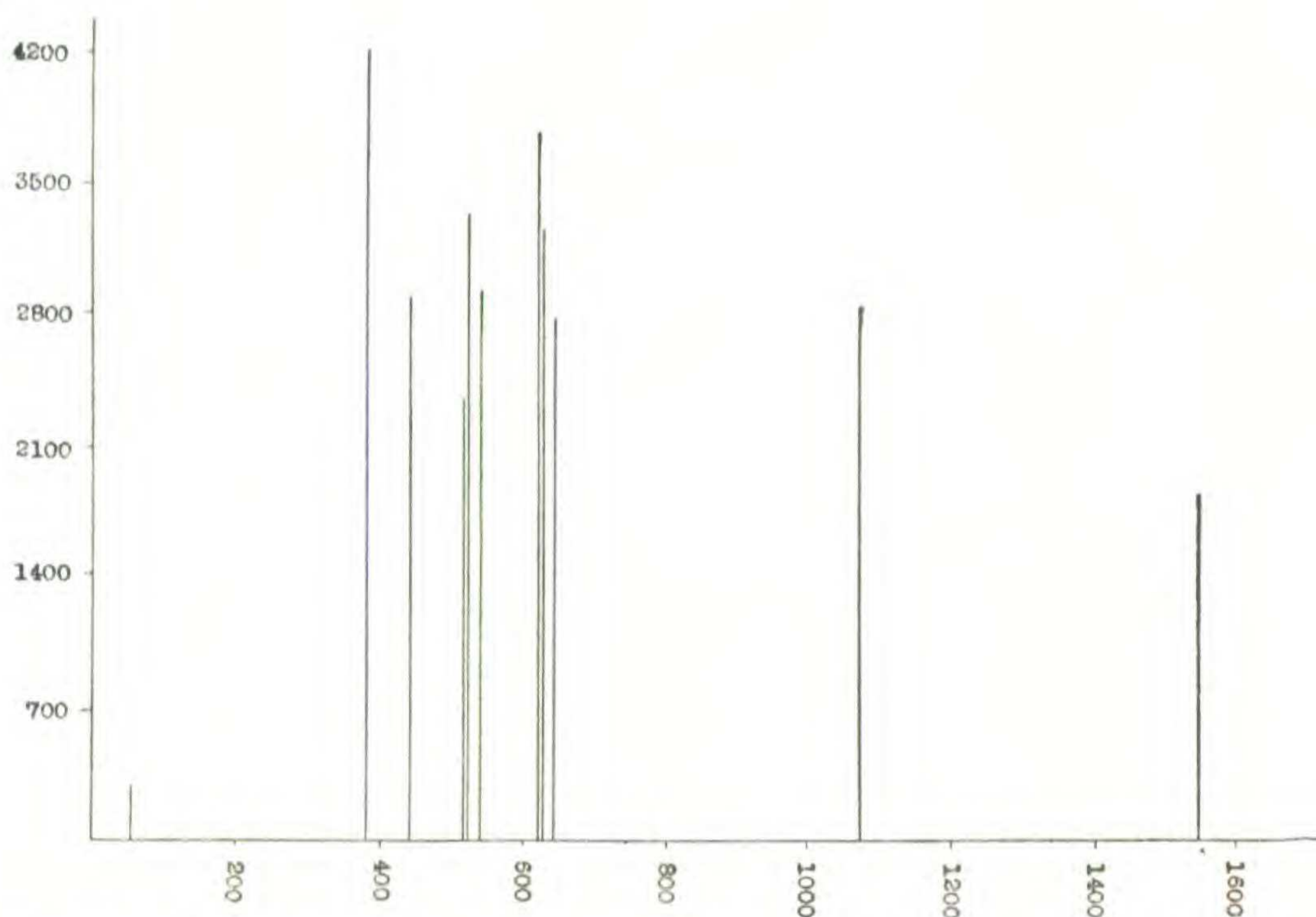


Fig. 6. The relation between growth and nitrate. Zinzadze, La Garde, Shive A, Knop, Knudson, Pfeffer, Crone, Sachs, Shive B, Schimper, Tottingham.

La Garde's solution also was strongly acid at the end of the experiment, probably because of the greater growth of the numerous seedlings upon it. The use of ammonium carbonate by

La Garde was probably for its buffer action against this undesirable change of acidity with growth. The effectiveness of the concentration of carbonate used as a buffering agent was tested by preparing La Garde's solution with and without carbonate and then comparing the titration curves obtained with N/100 hydrochloric acid. In both cases, the titration curves were

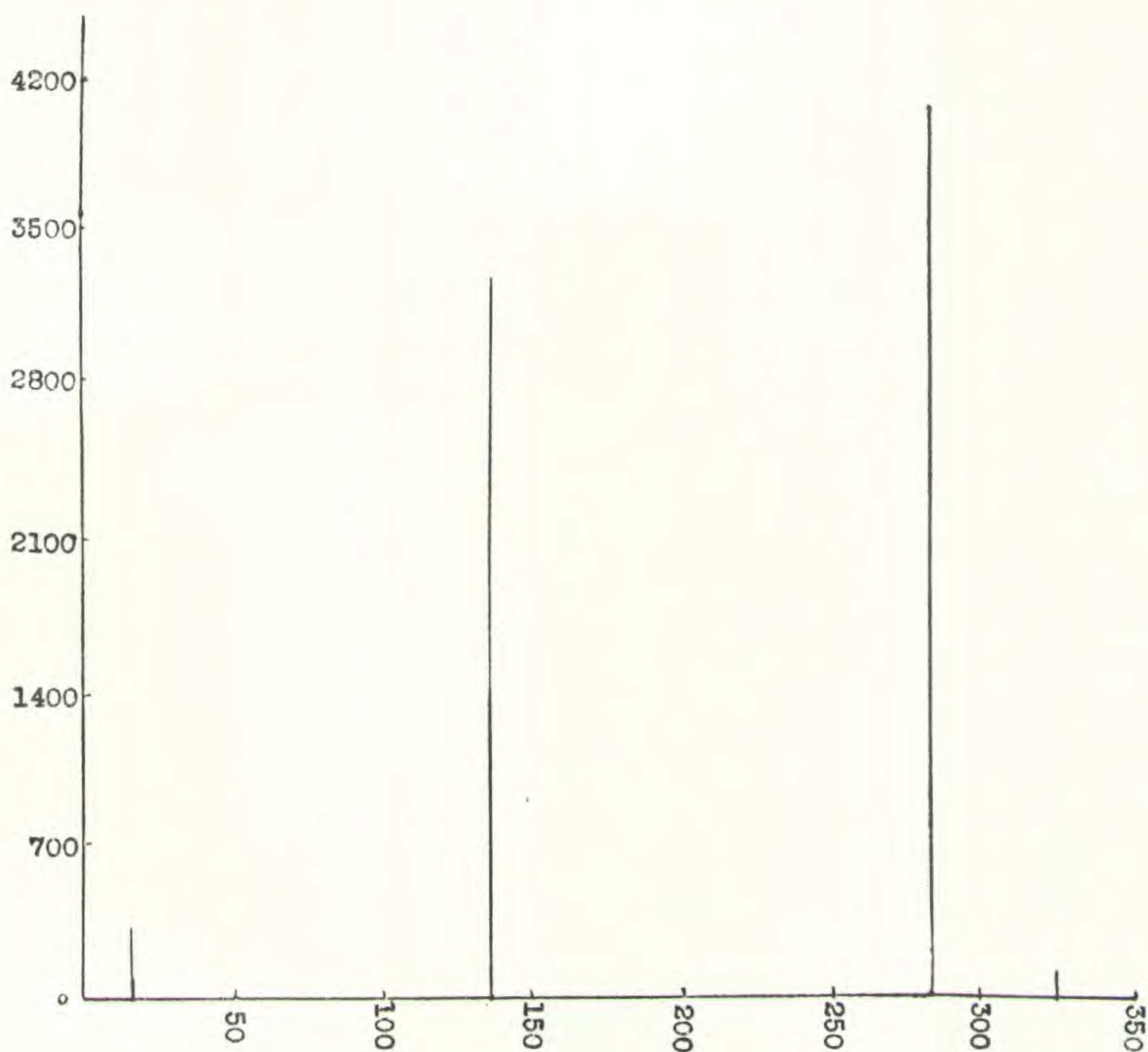


Fig. 7. Relation between growth and ammonia. Zinzadze, Knudson, La Garde, Hansteen-Cranner.

identical. The solutions were also analyzed for carbonate after autoclaving, but no positive test could be obtained. The autoclaving at 20 pounds pressure for 20 minutes at the initial pH necessary (4.25) undoubtedly destroyed the small amount of carbonate present.

Examination of table III shows that the best growth occurred on the solution of La Garde, followed by that on Crone's and

Knudson's. While the seedlings on La Garde's solution were conspicuously larger than those on Knudson's solution, the Knudson seedlings showed a definitely superior root development. The Crone seedlings were actually larger than those on Knudson's solution, but they did not appear to be so green. Of all the solutions tested, we would regard those of La Garde and Knudson to be the most satisfactory.

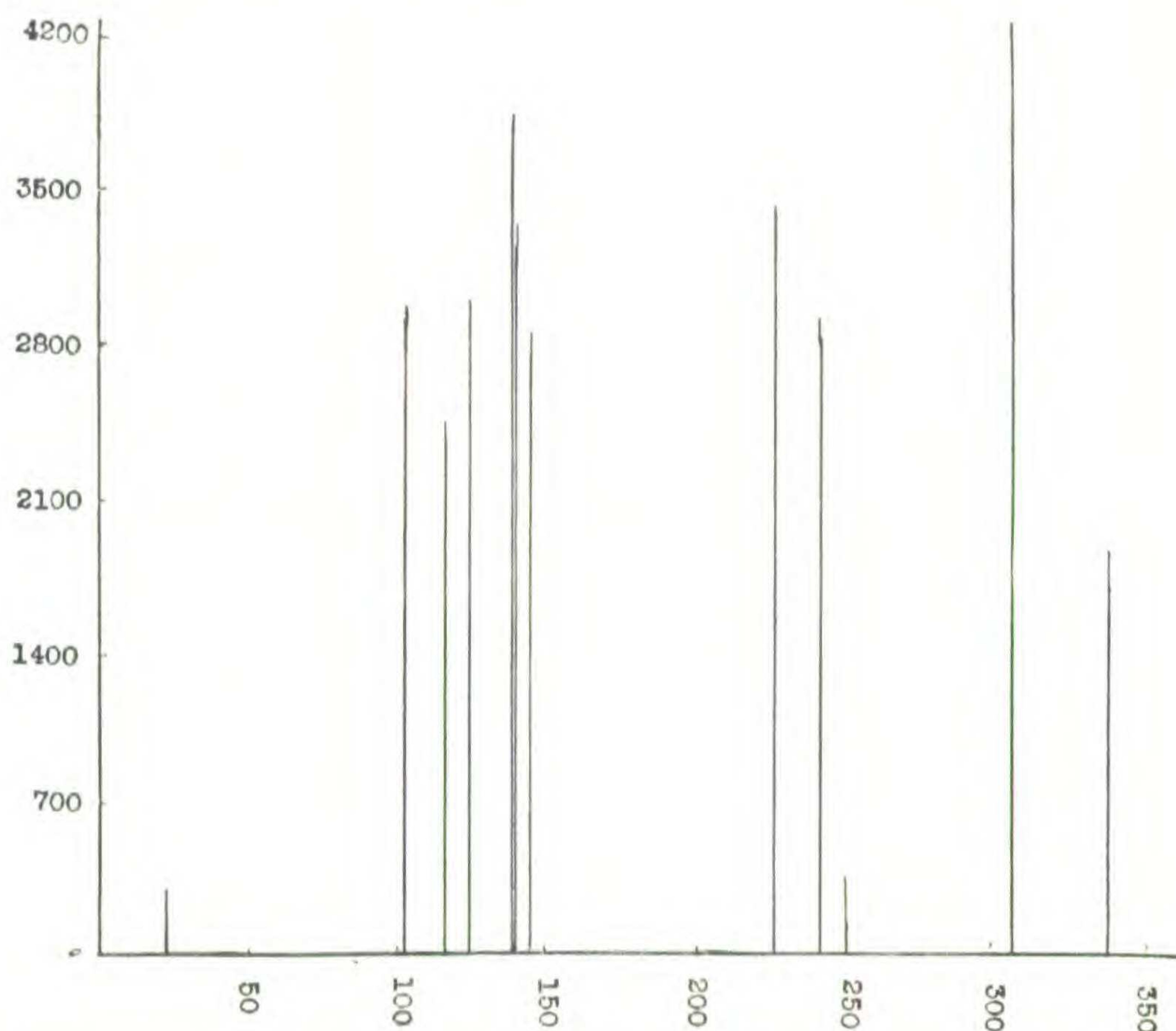


Fig. 8. Relation between growth and total nitrogen. Zinzadze, Shive A, Knop, Pfeffer, Crone, Sachs, Shive B, Knudson, Schimper, Hansteen-Cranner, La Garde, Tottingham.

The graphs indicate the comparative growth in relation to the concentrations in parts per million of each ion. It is apparent that the quality of the solutions is not related to a specific amount of any one ion. The author regards the superiority of La Garde's solution to be due to the particular complex of nutritional factors, and not to the specific effect of any particular ion. The nature of its superiority might well be a favorable condition of permeability of the cells produced by chemical means not yet understood.

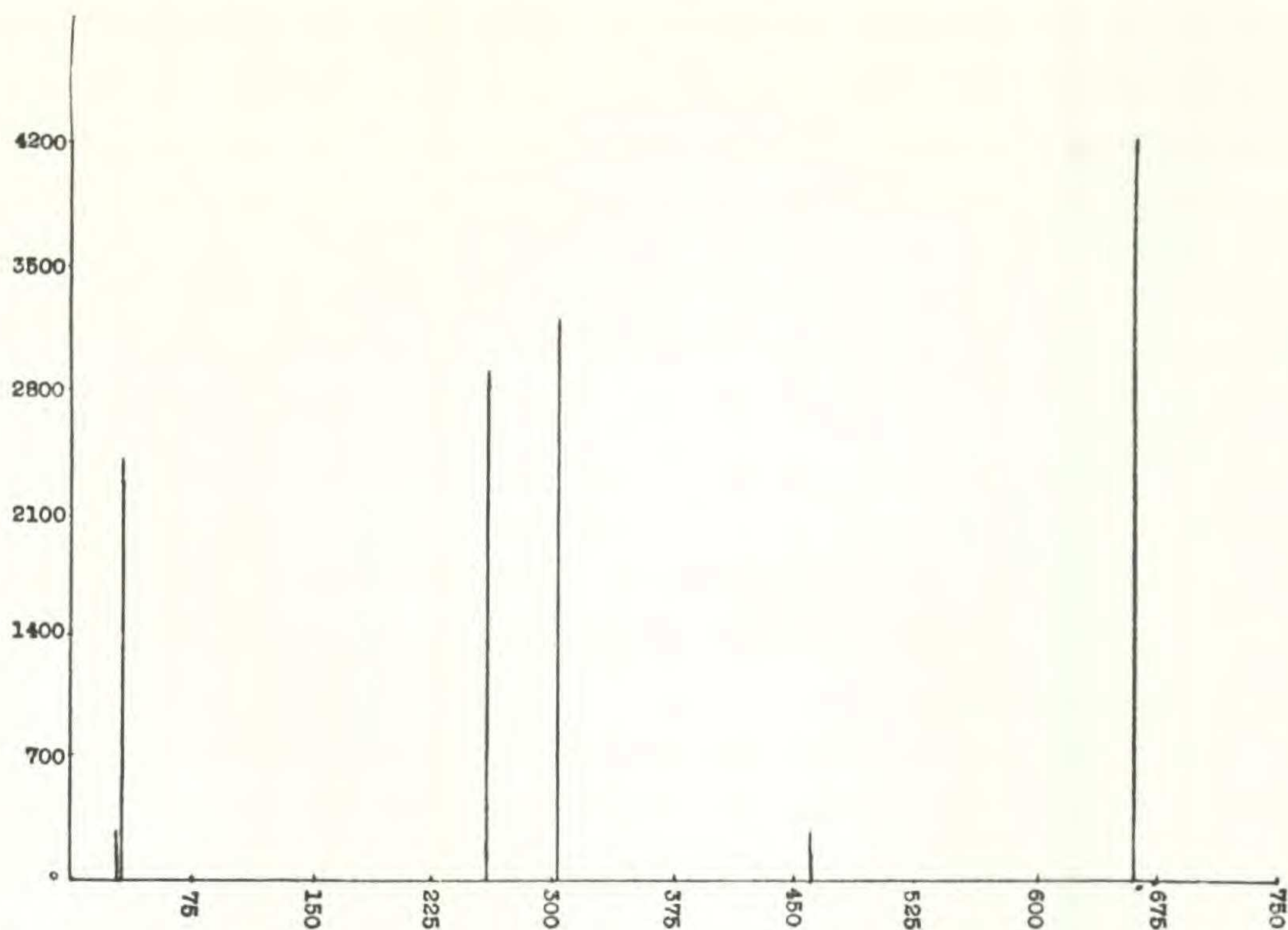


Fig. 9. Relation of growth to chlorine. Zinzadze, Knop, Schimper, Sachs, Hansteen-Cranner, La Garde.

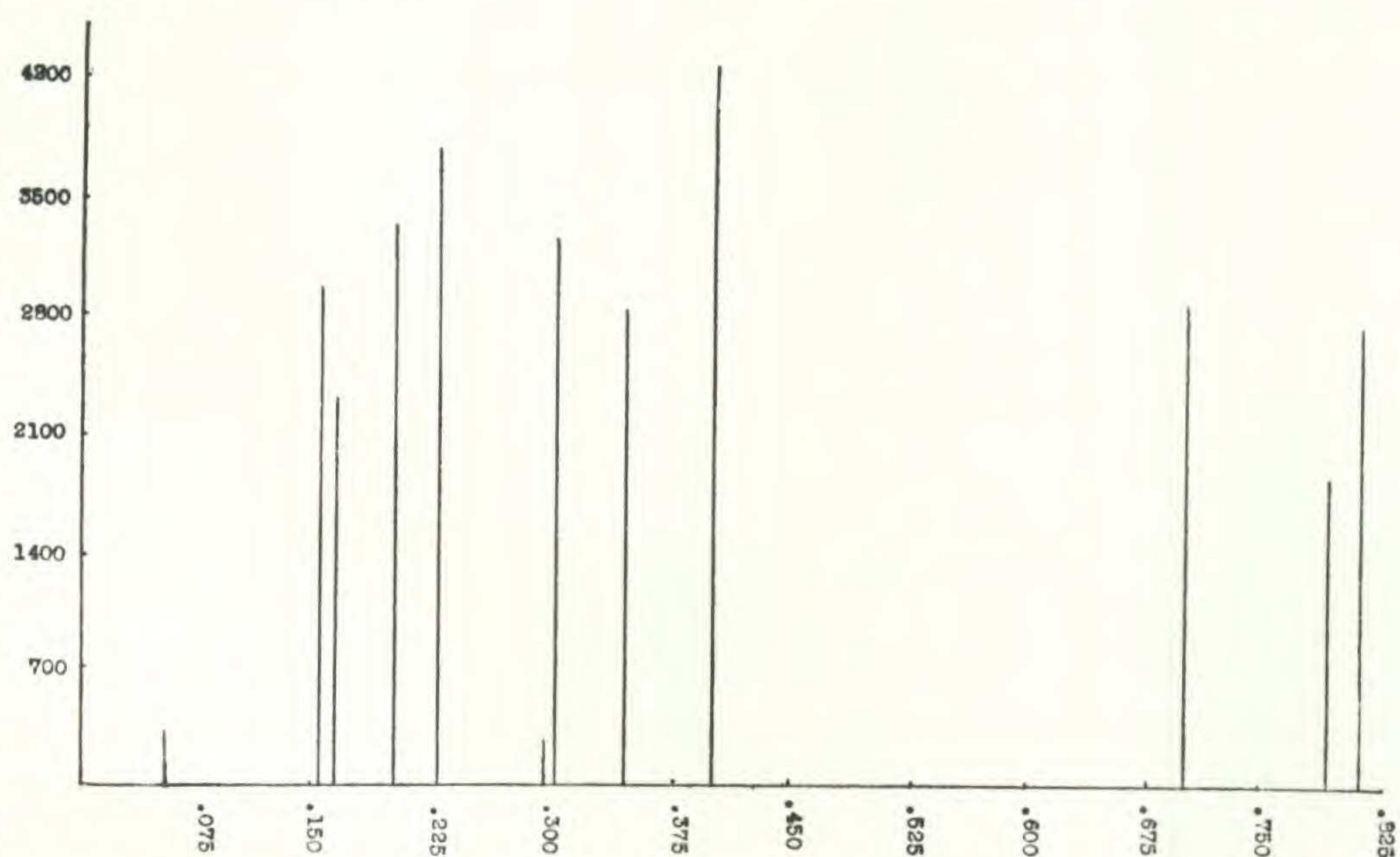


Fig. 10. Relation of growth to per cent total salt. Zinzadze, Pfeffer, Knop, Knudson, Crone, Hansteen-Cranner, Sachs, Schimper, La Garde, Shive A, Tottingham, Shive B.

In all figures, the vertical distance represents the height of the seedlings in microns, and the horizontal distance represents the

concentrations in parts per million of the ions indicated. The vertical lines representing the growth on the various media are listed from left to right.

CONCLUSIONS

1. Seeds of *Cattleya Trianae* Linden & Rehb. f., were germinated and grown on a number of published nutrient solutions. The best growth was obtained on La Garde's solution, which was closely followed by that obtained on the media of Crone and of Knudson.

2. No growth was obtained on the solutions of Hansteen-Cranner and Zinzadze. This was probably due to the unstable pH of these solutions.

3. The solutions studied differed in so many factors that the effects of any given species of ion were modified and obscured. Hence the nutritional value of the various solutions may not be interpreted as the effects of the concentrations of specific ions. This is clearly illustrated by the graphs.

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